

Assessment of Awareness Level towards Industry 4.0 Technology in Manufacturing Industry:

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Abstract. Fourth Industrial Revolution has recently been aware and occurred in developed countries' of manufacturing sector. However, some developing countries such as Ethiopian manufacturing awareness level towards Industry 4.0 (I4.0) technology was not known. The objective of this study is to assess awareness level towards I4.0 technology in Ethiopian Manufacturing Industry, a case of drinking Water Bottle Companies such as; Ambo Mineral Water Share Company, Top water Ethiopia and Gold Water and Non-alcoholic beverage. The study used both close ended with single and multiple response and open ended questionnaire to collect primary data from the respondents. The collected data was analysed using descriptive statistics (frequency and percentage) by using SPSS v27 software. The finding of this study shows that, the case companies knowledge regarding I4.0 concepts and its key technologies was insufficient. About 65 % of participants in this study indicate that the case companies were not aware with I4.0 concepts. Providing training for employee, preparing work shop with different stake holders, expert consultation, linkage with technology provider are the way of I4.0 implementations. The conceptual frame work of critical success factor for I4.0 implementation was developed for future research.

Key words: Industry 4.0, awareness level, manufacturing industry, technology adoption

1. Introduction

Industries have evolved and altered over time to produce better product and serve better communities and economies. New industrial technologies drastically changed peoples working conditions and lives. The history of industries started from hand production and then changed into mechanization systems during the 18th century and today's computer-aided and digitalized manufacturing system is on operation [1]. This change is called industrial revolution and since then, the world has gone through a drastic change. First industrial revolution use steam power for production, and the second revolution was more modern than the first revolution which electric engine replaced steam engine [2]. Still human need is un limited, use of electric engine didn't stopped the revolution, new revolution was continued which is called third industrial revolution where digitalization was started with partial automation where programmable logic controller was the technology used in the industry to control the overall production process [2].

Innovativity of individual person, organizations, and Industries competition at global market by itself and need of market for advanced products alter third revolution to fourth industrial revolution which is called I4.0. The term I4.0 was first introduced by Kagermann at the Hannover fair in

Germany in 2011 and furthermore, it was officially announced in 2013 as a Germany strategic initiative to take a pioneering role in industries which are currently revolutionizing the manufacturing sector [3]. I4.0 is a concept aimed at achieving the integration of physical parts of the manufacturing process and cyber parts via networks and driven by I4.0 technology categories used for prediction, control, maintenance, and integration of manufacturing processes. I4.0, which is expected to have a great impact on manufacturing systems in the future, is attracting attention in both industry and academia [4]. Innovations such as digitalization, internet of things, human-robot interaction, sensors, and communication protocols, intelligent industrial robots that can work together and make decisions, cyber security are realized with I4.0. Automated processes, intelligent machines concepts are components of I4.0 [5, 6]. The company which uses I4.0 digital technologies can increase production efficiency and get competitive advantage at global level [7]. Terra [7] summarize that, better quality of product and service, reducing of manufacturing time, and gradual growth in organizational performance is achieved by application of I4.0 technologies.

Adoption of I4.0 technologies can reduce lead time, improve forecast demand, reduce transportation cost, provide shipment route, and facilitate better collaboration between organization, supplier, and customer [8-10]. It enables company to detect product defect and increase product quality [7, 11, 12]. I4.0 has capability to predict machine failure and enable company to take preventive maintenance [13-15]. The reason behind the concept of I4.0 was aimed at the enhancement of productivity of manufacturing sector; it enables the company to increase productivity by reducing down time [14, 16, 17]. The articles by [18-20] state that, manufacturing sector get chance to organize huge data and plan, forecast demand with the help of I4.0.

The Fourth Industrial Revolution has recently occurred in manufacturing [21]. Strategies to increase industrial competitiveness through digital technology have proposed by different government worldwide, such as Germany's 'I4.0', 'strategy for American innovation' and 'made in china 2025 plan'. Integrating and digitizing internal operation are at the highest point in German and Japanese companies. Scandinavia countries have followed Germany and embraced I4.0 more quickly than other nations [21]. China and Australia are also highly investing in developing their strategy to implement I4.0 [22]. [23] Found that, United Kingdom planned for manufacturing industry which is called 'future of manufacturing' was implemented in 2013. France is another country which has clear industrial policy for the adoption of I4.0 [24]. In Malaysia, the government strictly took action by undertaking various efforts in helping industry players to adopt I4.0 through the implementation of automation and smart manufacturing [23]. South Korea is another Asian country where its manufacturing operation was performed by advanced technology [25]. There is significant improvement in adoption of I4.0 in Italian manufacturing [26]. Some of largest Iraq Companies have begun to use I4.0 technology; they adopt digital technology and smart manufacturing process [27].

However, in some country such as Ethiopian manufacturing awareness level towards I4.0 technology was not known. Lack of study on awareness level of I4.0 of manufacturing sector was there. Hence, the objective of this study is to Assess Awareness Level towards I4.0 Technology in Manufacturing Industries a case of drinking Water Bottle Companies such as; Ambo Mineral Water Share Company, Top water Ethiopia and Gold Water.

In this paper a brief introduction about I4.0 is provided in the first section and followed by Section 2, which contains literature on the I4.0 concept, the application of I4.0 and I4.0 key technologies. After that research methodology comes in Section 3, where the paper presents the method for data collection, target cases and data analysis tool. The data from the questionnaire and analysis of results are presented in Section 4, followed by a discussion of the findings in the same section. Section 5 gives the proposed solution and finally conclusion from this paper is discussed.

2. Literature Review

2.1. Concept of I4.0 and Its Benefit in Manufacturing Industry

I4.0 represent 4th industrial revolution which aimed at achieving the integration of physical parts of the manufacturing process (complex machinery, various devices, and sensors) and cyber parts (advanced software) via networks and driven by I4.0 technology categories used for prediction, control, maintenance, and integration of manufacturing processes. I4.0, which is expected to have a great impact on manufacturing systems in the future, is attracting attention in both industry and academia [4]. According to [28, 29], I4.0 is a concept that represent intelligent production process and the adoption by industrial companies of techniques and process allowed by digitization, cloud computing, the internet of things and big data to gain competitive advantages in domestic and global markets. Big data cyber physical systems, internet of things are new technologies which found under I4.0 that brings change in all manufacturing system [30]. It has been creating new opportunities for the manufacturing; the preparation of the company to adapt to this new era has great importance in terms of providing competitive advantage against their competitors [31]. The study in [28] indicate the transition to I4.0 is expected to cause formidable structural changes, productivity increments and competitiveness in manufacturing industry in all over the world.

According to the article [32], adoption of I4.0 can create better productivity and higher product efficiency for manufacturing. Product quality, process effectiveness and strategic planning capacities positively influenced by adoption of I4.0 technologies [33]. Narula et al. [34] state that, adoption of I4.0 has significant impact for manufacturing company on improvement of product quality, predicting maintenance, supply chain management (real time communication and collaboration), production planning (demand forecasting, online controlling). The reason behind the concept of I4.0 was aimed at the enhancement of productivity of manufacturing sector [35]. The finding conducted by AlZadjali and Ullah [35] implies that proper implementation of I4.0 can help productivity enhancement in manufacturing sector. I4.0 is not only making factory smart and also provide financial benefit by waste reduction [36] in manufacturing sector.

2.2. I4.0 key Technologies

I4.0 is the set of technologies, devices and process that allow for self-sufficient production models, capable of operating in an integrated way along the several phases of the production process and along the supply chain with minimum human intervention [29]. Technologies of I4.0 enable companies to achieve faster production output, better adjusted to customer needs, more efficient, with a lower ecological footprint, and with optimal resources' utilization [37]. I4.0 represents and considered a new industrial stage in which several emerging technologies are converging to provide digital solutions [38], the current trend of automation technologies in manufacturing industry and it mainly includes enabling technologies such as, Internet of things (IoT), cyber physical system, Mobile computing, big data, and cloud computing [39, 40]. Artificial intelligence, big data and additive manufacturing [41] are other key technologies of I4.0. Each key technology has its own application, opportunities and challenges in I4.0 era's on manufacturing sector. Jayaprakash et al. [42] state that, I4.0 goals will be accomplished by several different systems working together: the Internet of Things, Big Data and Analytics, Autonomous Robotic Systems, Simulation, Artificial Intelligence, Machine Learning, Cyber security, Cloud Computing, Additive Manufacturing, Augmented Reality, Cyber-physical system, and Smart Factories. The joint efforts of these systems will help to fulfill I4.0 goals.

Each key technology has high advantages in I4.0 era for manufacturing sector. Artificial intelligence refers to a computer or a computer-controlled machine's ability to perform tasks that are typically associated with high-level mental processes such as reasoning, inference, generalization, and learning from past experiences [43]. Gizealew [44] stated that, AI enables manufacturing to seeing more precise, higher quality product with lower operational cost, less down time because of predictive maintenance and intelligence in the supply chain, and fewer injuries on factory floor because of more adaptable equipment. It can enhance efficiency, improve demand planning, improve collaboration and increase agility in supply chain management [45]. Internet of things is one of digital technology which

enables manufacturing real time data collection, processing and analysis from range of equipment and helps in maintenance prediction [46]. Technology with the application of internet of things gives better quality products in efficient way, precise control is possible with the help of internet of things and enhances quality product output [43]. Cloud technology (cloud computing) can improve the aforementioned mechanism, permitting communication between all parties involved in the supply chain, including suppliers, assemblers, customers, and other service providers in manufacturing [7]. Increased data sharing across organizational boundaries, enhanced system performance (such as greater agility and flexibility), and lower costs by putting systems online are all possible with cloud technologies in I4.0. Consequently, it becomes more crucial to integrate cloud technology with industrial cyber physical system [47].

Digital Twin is a virtual representation of physical system and play great role in various industries that require high precision control and real-time analysis; it is used for maintenance planning and predictive equipment failure detection [43]. Big Data Analysis in supply chain enable to solve complex problem of supply chain management such us; delaying supplies, fuel cost and inconsistent supplier with the help of Big data analytics technologies Hadoop and cloud-based analytics [48]. Route optimization is the use of Big data in logistics and supply chain management, to designate the shortest route for the delivery vehicle [49]. Additive manufacturing is one of I4.0 key technology that joins materials to make objects based on 3D design data, usually in a layer-upon-layer manner; it is a means of rapid prototyping and manufacturing for components or products for actual end use [50]. Cyber security is one of I4.0 key technology which practice of defending computers, servers, mobile devices electronic system networks and company data from malicious attacks [44].

3. Research Methodology

This study hunted the opinions of three bottled drinking water manufacturers; Ambo Mineral Water Share Company, Top Water Ethiopia and Gold Water Bottling and Non-alcoholic beverage as shown in Table 1, on the issue surrounding the awareness level towards the I4.0 concept. A survey study approach was used to collect primary data from the three companies' respondents. Companies experts such as production managers, production line supervisors, quality controllers, maintenance engineers, logistics and supply chain experts, engineers and middle level workers, operators, etc., were the target group that was selected by the study to respond to the questionnaires. The case companies were selected by the use of convenient sampling, by considering the respondents proximity, accessibility and availability and relative approaches to technology. To collect data from the respondents', a questionnaire was designed and structured focusing on the awareness level of I4.0. The questionnaire cover; the level of awareness about the I4.0, I4.0 application area and its benefit, barriers to I4.0 implementation, the future plan for the implementation of I4.0 and awareness of each I4.0 key technology.

The questionnaire consisted of two parts. The first part has the respondents' profile, while the second part surveyed their awareness level towards the I4.0 concept. The questionnaire contained close ended question with a five-point Likert scale, (yes or no), multiple choice questions with a single option, multiple choices questions with multiple responses and open ended questions which enabled the respondents to be flexible and increases participations. To select the respondents for this study simple random sampling techniques were used. Accordingly, for this study general Yamane [51] formula was used to calculate a precise sample size with a 95% confidence level and $p = 0.5$ is assumed and given by Equation (1). The prepared questionnaires was printed in hard copy and distributed to the respondents after permission of the company management. All distributed questionnaires (248), were properly filled and returned for further analysis. Then, the collected data's were analysed using descriptive statistics (frequency and percentage) with SPSS version 27 software.

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

Where N=Number of Population, n= sample size and e= the degree of accuracy expressed as a proportion 0.05

Table 1. Sample size determination.

Organization	Total shift)	Population(day	Sample size	Time collected
Top water Ethiopia	110		86	April 27-30, 2026
Ambo Mineral water share company	108		85	May 11-14, 2026
Gold water	95		77	May 18-22, 2026
Total sample size			248	

4. Description of the Results

In this section, a brief description of questions and analysis of results from the questionnaire are provided.

4.1. *Personal details and demographic information of respondents participated on the survey*

The survey result shows 74.6 % of respondents were male while female participation was 25.4% as whole. The age of the participants were between 26-33 years with 79.4%, and 12.1% of respondents were between 34-41 years. Respondents between 18-25 years age was 4.4% and the remaining 4.0% were over 42 years. The educational background of respondents were first degree with 79.4% as shown from the result and followed by master's degree with 12.5% and 8.1% of respondents have diploma/TVET. The survey results show major of the company workers have 5-9 years of experience with 58.1%, while 29.0% have less than five years experiences and the remaining 12.9% of respondents have greater than ten years experiences. Operators were the most participant on this survey study with 42.3% and followed by quality controller with 17.3%. Production supervisor also participated than others position holder next to operator and quality controller with 12.9%. And manager, production manager, technical manager, safety manager, supply chain manager, procurement and property supervisor were also participated on the survey.

Concerning the information about respondents department, major respondents were from production department and quality department with 59.3% and 16.5% respectively. Maintenance department and finance office also followed equally with 7.3% whereas supply chain management department, risk management, property and procurement offices' workers participated with less percent when compared with other departments. The respondents of this study have different discipline area from diploma to master's level as the result shows from the survey. Electrical Engineering, Industrial Engineering, Mechanical Engineering, accounting and finance, business management, general mechanics, chemical engineering, industrial chemistry, applied chemistry and others were degree/diploma background of respondents which participated on the survey study.

4.2. *Survey results and analysis on Awareness level towards I4.0 technology in manufacturing industry.*

The questionnaire designed from three main parts as shown in Table 2 which include different questions under it with different method of responses.

Table 2. Main parts of questionnaires.

No.	Name of part	Aim of specific part	No. of questions
A	General Awareness of I4.0	To assess the awareness level towards I4.0 including its benefit and challenges of adoption	1-9
B	General awareness on key technologies of I4.0	To understand awareness level and familiarity of the company with digital technologies	10-15

C	Understanding concept of I4.0, and support needed to adopt I4.0	To know the knowledge of respondents about I4.0 and the support needed for adoption	16-17
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4.2.1. General awareness of I4.0 Concept. I4.0 requires high level of knowledge regarding digitization within the manufacturing industry to successful embracing transformation [23]. To identify the level of respondents' awareness towards I4.0 they were asked different related questions.

Awareness (implementation) on I4.0: Multiple choices given for the respondents to answer or to choose which belongs to their awareness level towards I4.0. Based on this, as it shown on Figure 1, 47.2 % of respondents know the term I4.0 but their company hasn't considered its implementation so far. Only 27 % responded that as their company is trying to implement I4.0 at right now and 6% witnessed as their company were dealing with I4.0 for more than one year, however 19.8% of respondents have not heard I4.0 topic, and they have no any awareness about I4.0. The result showed that, there is a variation between respondents on I4.0 awareness. There were some respondents who didn't know the term I4.0 at all in the companies. Also, the companies were not aware and doesn't considered I4.0 implementation yet.

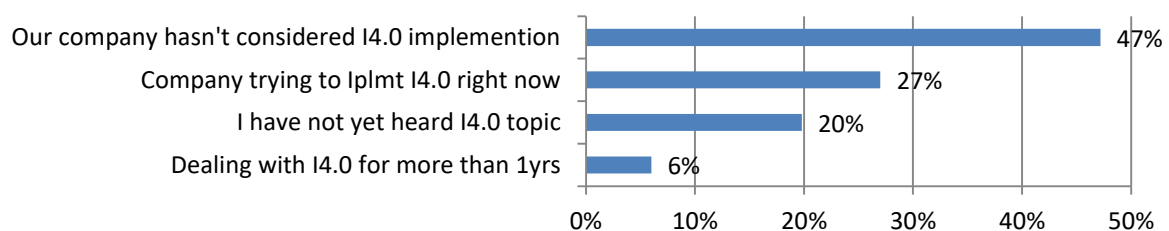


Figure 1. Implementation level towards I4.0.

Organizations awareness on I4.0 trends globally: Figure 2, shows that 64.9% of respondents have not at all awareness towards I4.0 right now. But 18.5% have slightly aware about I4.0 implementation in their organization. In addition, 11.3% somewhat aware and 4.8% moderately aware as founded from the result. Only 0.4% has highly aware about I4.0 and scales their organization about I4.0 trends globally. The result shows that, the company's awareness level towards I4.0 was very low. Around 65% of respondents were not aware towards I4.0. This low level of awareness negatively affects organizations' readiness to adopt I4.0 technologies because employee knowledge and understandings are very important for implementation of I4.0.

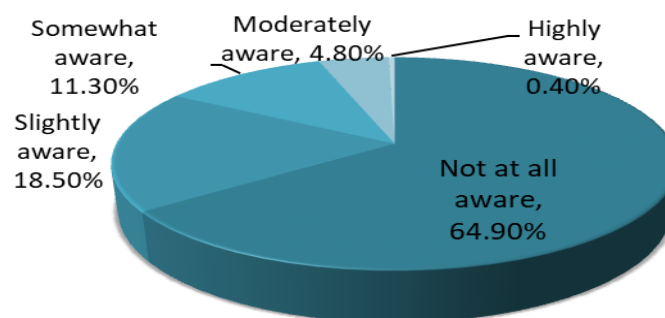


Figure 2. Organizations level of awareness towards I4.0 trends.

Purpose of I4.0 adoption: The questionnaire was designed for respondents to select multiple options which focus on purpose of I4.0 if the company were adopting it. As a result, more than 72% of respondents were selected the benefit that I4.0 gives for the company once it adopted as shown in Figure 3. It means that 78.6% selected purpose of I4.0 on predictive maintenance, 77% quality control (detect defect), 75.4% use of I4.0 for production planning and control, 72.2% and 75.4% of respondents selected advantage of I4.0 on supply chain management and improvement on product design respectively, whereas, 9.3% select not interested to deal with I4.0. The result implies, adoption of I4.0 play great role as high number of respondents response regard with predicting maintenance, quality control, production planning and control, supply chain management and product design improvement.

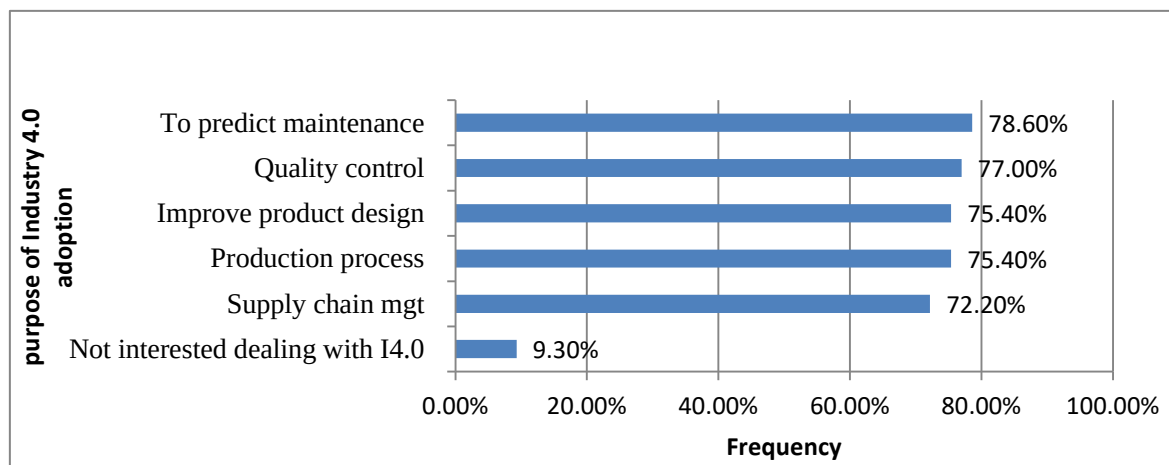


Figure 3. Potential benefit from I4.0 implementation for the company.

Benefit gained from Implementation of I4.0 according to different studies: Figure 4 illustrate that 85.5% strongly agree on implementation of I4.0 enables the company to enhance their productivity, increase flexibility, cost efficiency, improve sustainability and improve competitiveness. In addition, 7.3% of them were neutral and other 7.3% of respondents agree on the statement of I4.0 implementation. In general, the result indicates the implementation of I4.0 enables the companies to enhance their productivity, increase flexibility, cost efficiency, improve sustainability and improve competitiveness.

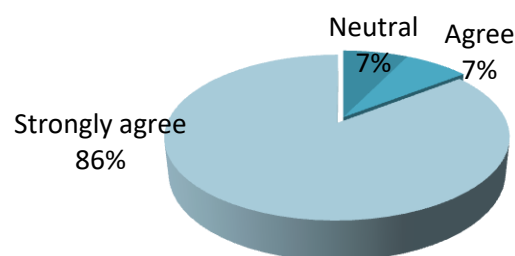


Figure 4. Agreement of respondents with different scientific studies on benefits of I4.0 adoption.

Challenges that may face organization in adopting I4.0: There are significant benefits in I4.0 and there are some serious concerns in front of manufacturers that need to be considered and handled [39]. Having this concept the researcher listed for respondents to select which barriers affects the company from I4.0 adoption. Hence, Figure 5 illustrates 79.6% of respondent select lack of infrastructure is the

barriers of adoption of I4.0 for the company. Both high investment cost and lack of awareness of technology/standard for implementation selected equally with 73.1% by respondents next to infrastructure, and 72.2% respondents selected lack of research and development in the company challenges implementation of I4.0. Absence of technology provider, lack of understanding of top management, lack of skilled were selected by respondents with 71.0%, 69.8% and 69.4% respectively which are another barriers in adoption of technology. 46.1% of respondents recognize lack of top management and 42.9% cyber security as challenges of industry in I4.0 adoption. Also lack of commitment of business owner and uncertainty of economic benefit after implementation of I4.0 technology get minimum selection with 28.2% of respondents. As shown on the result, the participants agreed on the obstacles of I4.0 implementation that mentioned in the questionnaire. There are several challenges which face companies during implementation of I4.0 according to the results

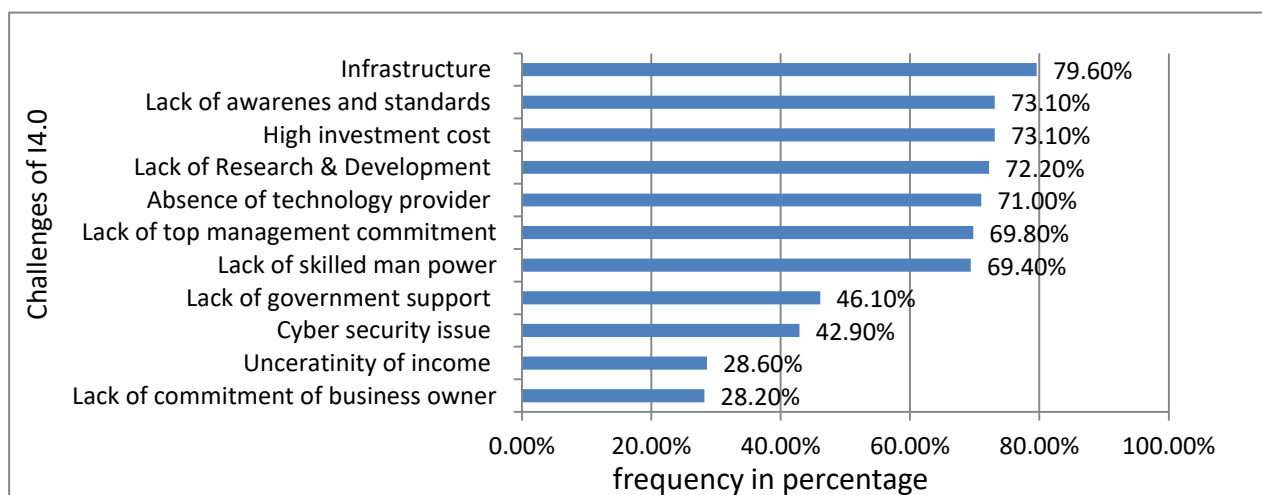


Figure 5. Obstacles in the ways of I4.0 implementations.

Company future plan on I4.0 implementation: With regard to future plan of the company on I4.0 implementation 64.1% mentioned as it is not planned for implementation whereas 35.9% illustrate plan of the company towards I4.0 implementation as shown in Figure 6. The result indicates that, the selected manufacturing companies have a relatively low level of preparedness of future plan towards implementation of I4.0 technologies.

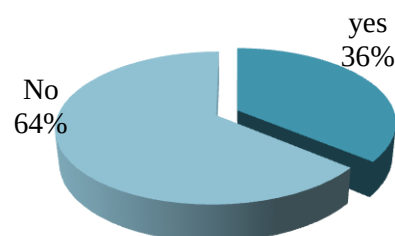


Figure 6. Respondents' response on the companies' future plan on I4.0 implementation.

Sufficient knowledge of company to implement I4.0: Concerning the sufficient knowledge of the company to implement I4.0 technology, the result illustrated in Figure 7. As a result, 47.6% of respondents disagreed and 2.8 % strongly disagreed on it, whereas only 16.1% agreed and 2% strongly agreed, but 31.5% were neutral on the term. The finding indicates that, more than half of the

respondents did not agree on the sufficient knowledge of the company to implement I4.0. It means that, the companies have limited knowledge towards implementation of I4.0. This could be related to generally low level of awareness of I4.0.

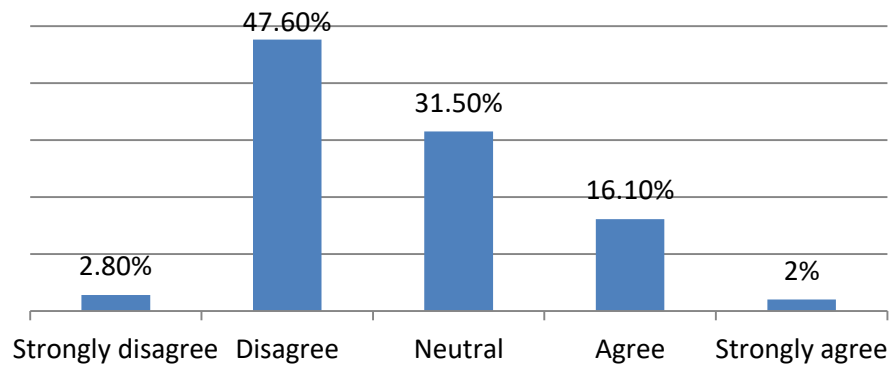


Figure 7. Responses of respondent on companies' knowledge on I4.0 implementation.

Companies' clear strategies of adopting I4.0: Figure 8 illustrates with regard to the company clear strategy for adopting I4.0, 25.8% respondents were neither agree nor disagree, whereas 14.1% agreed and 3.6% strongly agreed. But 52.0% respondents were disagreed and the remaining 4.4% respondents strongly disagree with their company's strategy to implement I4.0 technologies. The finding indicate that, the majority of respondents (more than 55%) do not believe that their companies have a clear strategies towards I4.0 implementation. This implies that, the selected companies may lack adequate strategic planning and organizational preparedness for the adoption of I4.0.

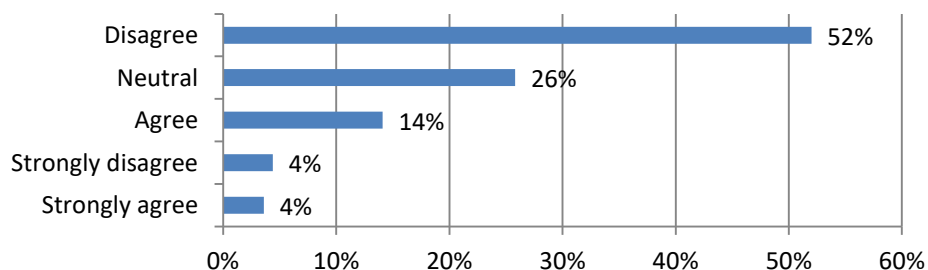


Figure 8. Level of respondent response on companies clear strategies to adopt I4.0.

Availability of skilled personnel in the company to implement I4.0: The survey result in Figure 9 illustrated that, the respondents strongly agreed and agreed regard with availability of skilled personnel in the company for implementation of I4.0 was 7.7% and 10.9% respectively. 31.0% were neither agree nor disagree. But 47.2% disagree with term and 3.2% were also strongly dis agreed. More than 50% of participants not agreed with the availability of skilled personnel in the selected companies for the successful implementation of I4.0. This suggest that, the companies may not yet have sufficient human resource with technical knowledge and skills required to operate and adopt I4.0.

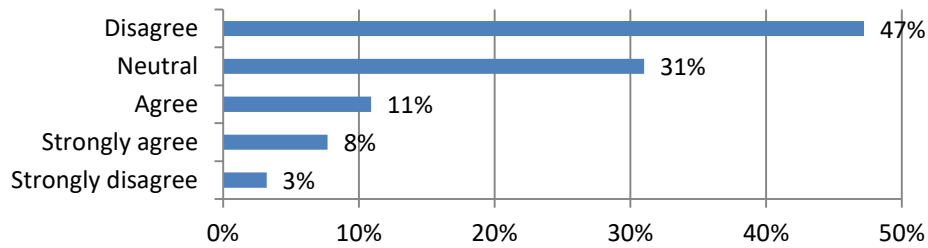


Figure 9. Level of skilled personnel in the companies to adopt I4.0.

4.2.2. General Awareness on I4.0 key Technologies. Awareness level on I4.0 key technologies: Concerning the survey question of general awareness of I4.0 key technologies, 58.5% didn't aware of key technologies whereas 41.5% knew about I4.0 key technologies as it shown from Figure 10. The finding implies that, the overall level of awareness of I4.0 key technologies among the respondents is relatively low.

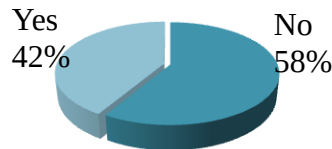


Figure 10. Awareness level of I4.0 key technologies in the companies.

Awareness level for each I4.0 key technologies: Concerning key technologies that the respondents were not familiar with as shown in Figure 11 indicate that, the respondents were not familiar with mentioned I4.0 technologies. More than 65% in average of respondents didn't select the key technologies mentioned on multiple choices by the researcher. Majority of respondents have low awareness level towards mentioned I4.0 key technologies such as cyber security, Big Data, Artificial intelligence and cloud computing. Very small number of participants aware with I4.0 key technologies mentioned. Internet of things and robotics were somewhat known by some respondents when compare with others key technologies.

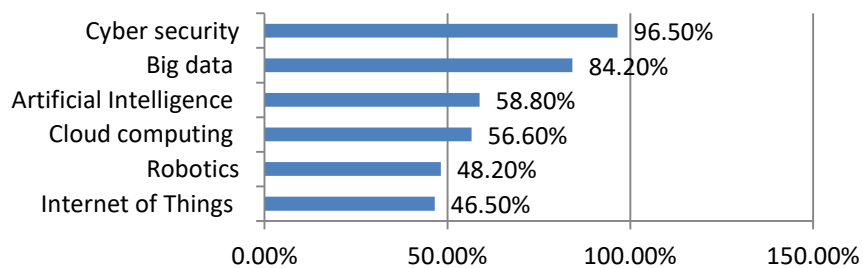


Figure 11. Level of key technologies which are not familiar with companies.

I4.0 key technologies used by the company: The survey result shown in Figure 12 (a) indicates that, more than 69% of participants implies the companies were not using I4.0 key technologies. Figure (b) illustrate that, the companies respondents mentioned PLC and Sensor which technologies currently used by the companies out of the listed on multiple choice of the survey questionnaire. But

97.2% didn't mention any technology which their companies use currently. It indicates that, the mentioned I4.0 key technologies were not used by the selected manufacturing companies. The companies were not dealing yet with cloud computing, Big data, cyber security, Artificial intelligence, robotics and internet of things.

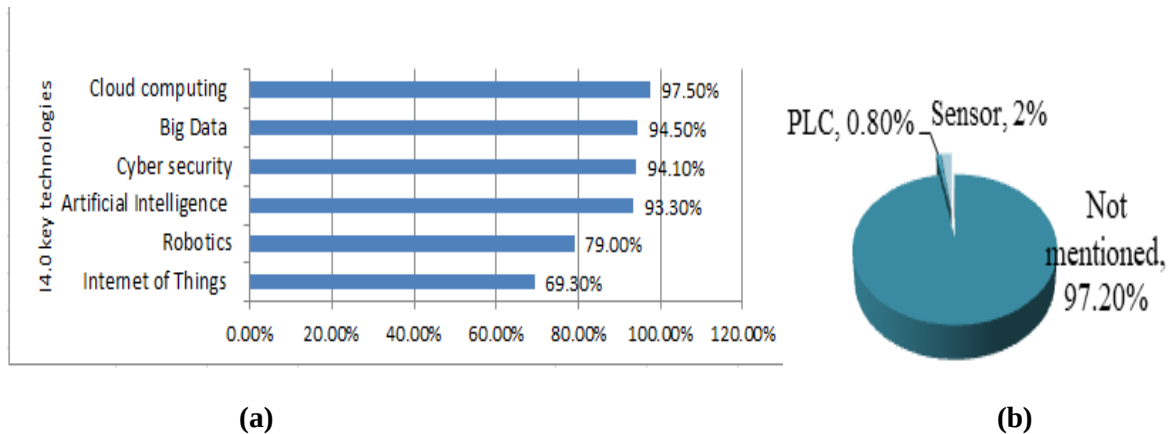


Figure 12 (a) and (b). Overview of key technologies and implementation level.

I4.0 key technologies opportunities: Concerning with opportunities of I4.0 key technologies for the company as general 84.7% agreed as shown in Figure 13. But, 15.3% not agreed the opportunities that company gets from adoption of digital technologies. The finding indicates that adoption of I4.0 key technologies have great opportunities for the companies. The key technologies enable the companies in quality prediction, supply chain management, maintenance prediction and productivity enhancement.

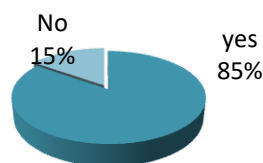


Figure 13. Respondent opinion with opportunities of I4.0 technologies implementation.

Company future plan for I4.0 key technologies: The finding on the survey concerning with future plan of the company to implement I4.0 key technologies shows, 37.9% responds as the companies have planned to implement, but high number of respondents 62.1% illustrate as the company didn't have plan right now to implement I4.0 key technologies. The result indicates that, the selected manufacturing companies have a relatively low level of preparedness of future plan towards implementation of I4.0 key technologies.



Figure 14. opinion of respondent on future plan to implement I4.0 technologies.

Digital technologies that the companies plan to implement: concerning I4.0 key technologies planned by company for future implementation, more than 71% of respondent didn't agreed with as shown in the Figure 15. Which mean that the company didn't planned to implement the mentioned technologies. Less than 29% of respondents selects as the company plan to implement for the future.

In general, the majority of respondents not agreed with their company's' plans to implement the mentioned I4.0 key technologies. It implies that, the selected manufacturing companies have a relatively low level of preparedness of future plan towards implementation of digital technologies.

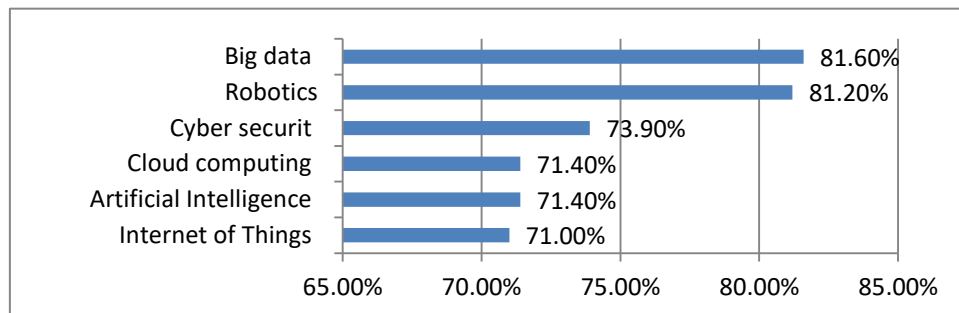


Figure 15 . Technologies level which company doesn't planned for future to implement.

4.2.3. Open ended question related with understanding definition of I4.0 and support needed to adopt. Open ended question designed and provided for respondents to reflect their opinion on level of understanding of definition of I4.0 and supports needed to improve awareness and its adoption.

Understanding the definition of I4.0: The survey on open ended question which concerned with the understanding of the concept (definition) of I4.0 as illustrated in Figure 16 shows that, 20.2% of respondents mentioned un related definition with the concept of I4.0 and 8.9% can't able to give any definition of I4.0. But, 25.8% understood that I4.0 is digital technology, 22.2% define I4.0 is integrated system. In addition, 18.1% responds I4.0 is smart manufacturing and the remaining 4.8% understood as I4.0 is advanced, model and latest technology. The finding indicates that, about 29% of respondents didn't understand the concept of I4.0. Whereas, the rests of respondents gave different responses on the concepts of I4.0. It implies that, awareness level towards the concept of I4.0 of the respondents was not the same.

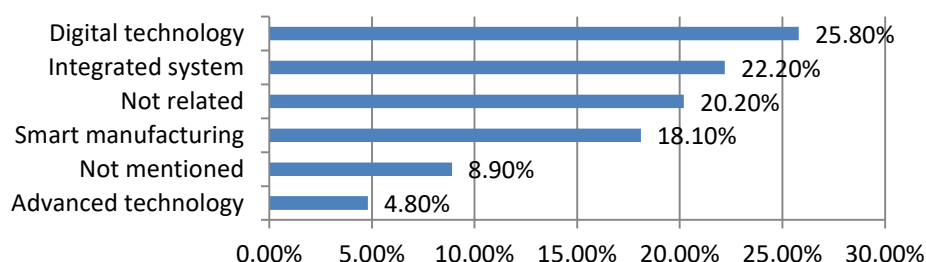


Figure 16. Assumptions of respondents on the definition of I4.0

Support needed to improve awareness and adoption of I4.0: The finding in Figure 17 indicates that most of the respondents mentioned the support needed for I4.0 implementation for open ended survey provided for them. 31% of respondent indicate that training and capacity building for workers is important issue to improve awareness of concept of I4.0 and its implementation. Technology support 12.1%, expert consultation 4.8%, strategic planning and top management commitment 10.5%,

research centre 7.7% and different workshop program 8.5% were another support as mentioned by respondent to improve awareness and adoption of I4.0 technologies for the companies. But, 16.5 % didn't mention any supportive things which may upgrade awareness level towards I4.0 technologies and its implementation. In general, providing training for the employee, preparing work shop by collaborating with different stake holders, expert consultation are the way of I4.0 implementations. Top management commitment, linkage with technology provider and collaboration with research or technology institute improve I4.0 adoption.

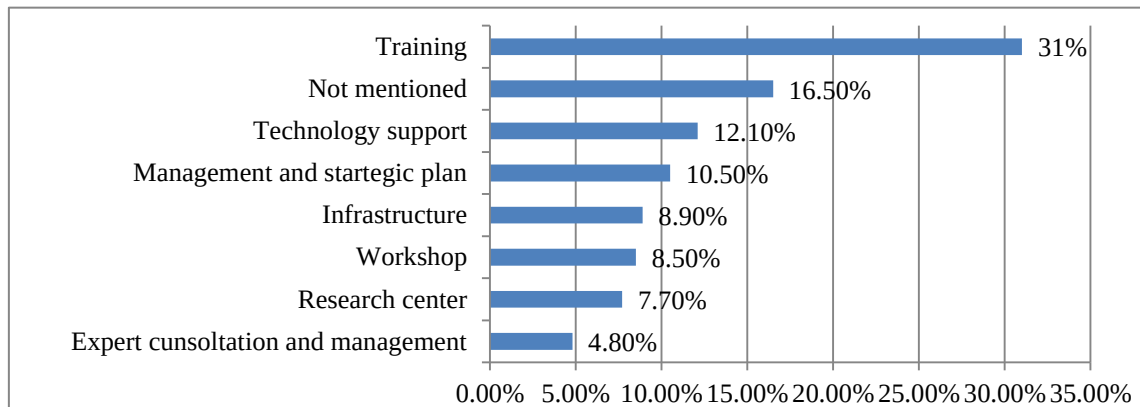


Figure 17. Support needed to improve awareness and adoption of I4.0.

5. Conclusion

The study was done on Ambo Mineral water Share Company, Top water Ethiopia and Gold water bottling and Non-alcoholic beverage industries to assess awareness level towards adoption of I4.0 technologies of these companies. Data was collected from the three companies of workers who work day shift during the data collection based on questionnaire designed. The result analysed by the use of SPSS software V.27 and interpreted. The result shows that about 65 % of participant in this study indicate not aware with I4.0 concepts. The study found that, the companies are not familiar with I4.0 technologies; artificial intelligence, Internet of things, cloud computing, big data, and robotics right now. There is lack of skilled personnel, lack of knowledge in I4.0 and lack of future plan on I4.0 implementation as the companies' participants indicated. As mentioned by different participant, providing training for the employee, preparing work shop by collaborating with different stake holders, expert consultation are the way of I4.0 implementations. Top management commitment, linkage with technology provider and collaboration with research or technology institute improve I4.0 adoption.

Future research work

1. To study the key drivers affecting the adoption of I4.0 in manufacturing industries: A case Beverage industries.

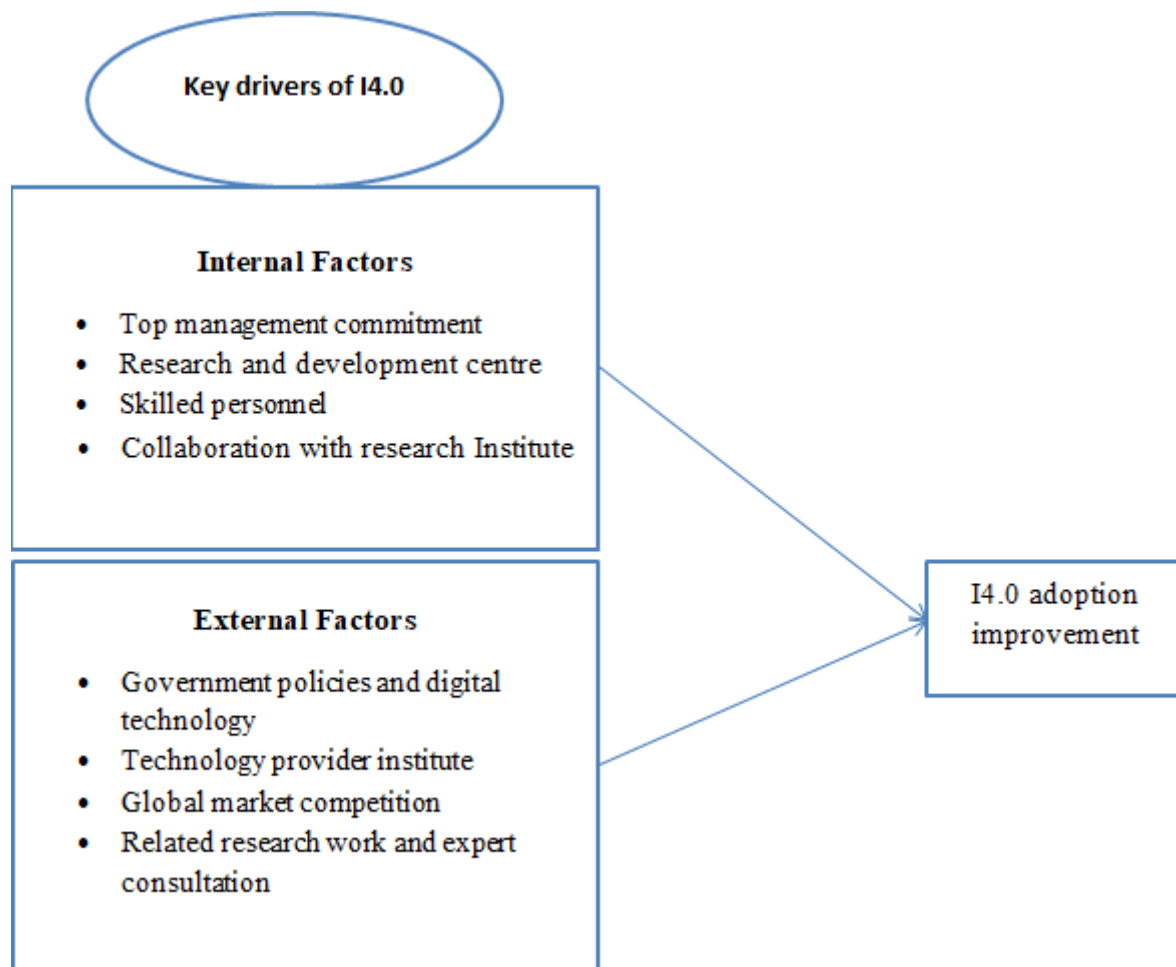


Figure 18. Conceptual frame work on I4.0 implementation key drivers

References

- [1] Bakhtari R A, Waris M M, Sanin C and Sxxzerbicki E 2021 Evaluating I4.0 implementation challenges using interpretive structural modelling and fuzzy analytic hierarchy process, *Cybern. Syst.* DOI:10.1080/01969722.2020.1871226
- [2] Mohajan K H 2021 Third Industrial revolution brings global development, *J. of Social science and humanities.* 7 (4), 239-251, <http://www.aiscience.org/journal/jssh>
- [3] Pasi B N, Mahajan S K and Rane S B 2020 The current sustainability scenario of I4.0 enabling technologies in Indian Manufacturing Industries, *Int. J. of Productivity and Performance Management.* DOI 10.1108/IJPPM-04-2020-0196
- [4] Bajic B, Rikalovic A, Suzic N and Piuri V 2020 I4.0 Implementation Challenges and opportunities: A managerial perspective, *IEEE Syst. J.* DOI:10.1109/JSYST.2020.3023041.
- [5] OCAK S B, Demircan O, Gökmen U, Alakavuk E, Akay D and Sari F, et al. 2020 *Engineering on Energy Materials*, Ankara (Turkey): iksad publishing house. 53p.
- [6] Branco C I, Cruz-Jesus F and Oliveira T 2019 Assessing I4.0 readiness in manufacturing: Evidence for the European union, *Comput. Ind.* **107**, 22-32
- [7] Terra J D. R, Berssaneti F T and Quintanilha J A 2022 Challenges and barriers to connecting world class Manufacturing and continuous improvement process to I4.0 Paradigms. *Eng. Manag. Prod. Serv.* **13**(4), 115-130. doi: 10.2478/emj-2021-0035

- [8] Zheng T, Ardolino M , Bacchetti A and Perona M 2020 The Application of I4.0 Technologies in Manufacturing Context: a systematic literature review. *Int. J. Prod. Res.* <https://doi.org/10.1080/00207543.2020.1824085>
- [9] Kumari N, Chaudhary D, Kaur H and Yadav A L 2023 Artificial Intelligence in supply chain Optimization. *International Conference on IoT, communication and Automation Technology (ICICAT)*. IEEE. DOI: 10.1109/ICICAT57735.2023.10263631
- [10] Stentoft J, Kent A W, Philipsen K and Haug A 2020 Drivers and barriers for I4.0 readiness and practice: Empirical evidence from small and medium sized manufacturers, *PPC*, DOI: 10.1080/09537287.1768318
- [11] Masood T and Sonntag P 2020 I4.0 Adoption Challenges and Banefit for SMEs, *Comput. Ind.* 1-26.
- [12] Narula S, Prakash S, Dwivedy M, Talwar V and Tiwari S P 2020 I4.0 adoption key factors: an empirical study on manufacturing Industry, *J. Adv. in Management Research*. DOI 10.1108/JAMR-03-2020-0039
- [13] Barasa S and Etene Y 2023 Robotics in food manufacturing Industry in the I4.0 era. *I. J. Comput. science and mobile computing*. **12**(8), 72 – 77. DOI: <https://doi.org/10.47760/ijcsmc.2023.v12i08.009>
- [14] Costa F, Frecassetti S, Rossini M and Staudacher A P 2023 I4.0 digital technologies enhancing sustainability: Application and barriers from the agricultural industry in emerging economy. *J. Cleaner Production* **408**, 137208.
- [15] Piovano A, Verna E, Genta G and Galetto M 2025 I4.0 enablers in food industry: a framework based on stakeholder challenges in quality and sustainability. *Int. J. Qual. Reliab. Manage.* **43**(2), 349-372. DOI 10.1108/IJQRM-04-2025-0120.
- [16] Kumar P, Bhamu J and Sangwanc K S 2021 Analysis of Barriers to I4.0 adoption in manufacturing Organization: an ISM Approach. 28th CIRP Conference on life cycle Engineering. *Procedia CIRP* **98**, 85–90.
- [17] Rahman M, Emon E H, Antor M H, Haque S A and Talapatra S 2024 Identification and prioritization of barriers to I4.0 adoption in the context of food and beverage industries of Bangladesh. *Benchmarking: Int. J.*
- [18] Telukdarie A, Munsamy M, Katsumbe T M, Maphisa X and Philbin S P 2023 I4.0 Technological advancement in the food and beverage manufacturing industry in South Africa- Bibliometric Analysis via Natural Language Processing. *Inf.* **14**, 454. <https://doi.org/10.3390/info14080454>
- [19] Contador J C, Satyro W C, Contador J L and Spinola M M 2020 Flexibility in the Brazilian I4.0: challenges and Opportunities. *Global Journal of Flexible Systems Management*. <https://doi.org/10.1007/s40171-020-00240-y>
- [20] Bravi L and Murmura F 2021 I4.0 enabling technologies as a tool for the development of a competitive strategy in Italian Manufacturing Companies. *J. Eng. Tech. Manage.* **60**, 101629
- [21] Bonkenburg T 2016. Robotics in Logistics. March.” DHL Trend Research. Accessed 14 September 2019. https://www.dhl.com/content/dam/downloads/g0/about_us/
- [22] Hamzeh R, Zhong R and Xu X W 2017 A survey study on I4.0 for New Zealand manufacturing. *Procedia manuf.* **26**, 49-57
- [23] Al-Amin, Bhuiyan M R I, Rashed Hossain R, Molla C, Tahmina Akter P T and Milon M U 2024 The Adoption of I4.0 by using the Technology Organizational Environment Framework. The Mediating Role to Manufacturing Performance in developing country. *Business Strategy & Development*. **7**(2), 363. <https://doi.org/10.1002/bsd2.363>
- [24] Liao Y, Deschamps F, Freitas E D and Loures R 2017 Past, present and future of I4.0: A systematic literature review and research agenda proposal. *Int. J. Prod. Res.* **55**(12), 3609-3629
- [25] Nguyen T, Hiena T 2025 Evaluating barriers to I4.0 adoption in Asian manufacturing enterprise: A funnel plot analysis approach. *Dalat University journal of science*. **16**(1), 3-25
- [26] Zheng T, Ardolino M, Bacchetti A and Perona M 2023 The road towards I4.0: a comparative study of the state-of-the-art in the Italian manufacturing industry. *Benchmarking: An international journal*. **30**, 307-332

- [27] Mannadhan P, Szymanski J R, Zurek-Mortka M and Sathiyarayanan M A 2024 Novel framework for the Iraqi manufacturing Industry towards the adoption of I4.0. Sustainability. **16**, 9045. <https://doi.org/10.3390/su16209045>
- [28] Sari T, Gule H K and Yigitol B 2020 Awareness and readiness of I4.0: the case of Turkish Manufacturing industry. Adv. production Engineering and management. **15**(1), 57-68
- [29] Branco C.S, Cruz-Jesus F and Oliveira T 2019 Assessing Industry 4.0 readiness in manufacturing: Evidence for the European Union. Comput. Ind. **107**, 22–32.
- [30] Yilmazi K, Ozdagoglu A 2020 Awareness analysis of industrial 4.0. Mehmet Akif ersoy university j. of social sciences institute. **31**, DOI 10.20875/makusobed.459431
- [31] Cetinkaya A S and Unsacar KM 2021 Assessment of I4.0 on manufacturing enterprise: demographic perspective. Adv. in global services and retail management. **2**
- [32] Tortora M R, Maria A, Valentina D, Iannone R and Pianes C 2021 A survey study on Industry 4.0 readiness level of Italian small and medium enterprises. Procedia Comput. Sci. **180**, 744–753
- [33] Romanello R, Veglio V 2022 I4.0 in food processing: Drivers, Challenges and outcomes. Br. Food J. **124**(13), 375-390
- [34] Narula S, Prakash S, Dwivedy M, Talwar V and Tiwari S P 2020 Industry 4.0 adoption key factors: an empirical study on manufacturing Industry. J. Adv. Management Research. DOI 10.1108/JAMR-03-2020-0039
- [35] AlZadjali S and Ullah A 2021 Impact of I4.0 in Manufacturing Sector. Int. J. Manage. Sci. Bus. Adm. **7**(6), 25-33,
- [36] Ngepah N, Saba C S and Kajewole D O 2024 The impact of I4.0 on south Africa's manufacturing sector. J. Open. innovation: Technol, Mark, and Complexity. **10**, 100226.
- [37] Jankowska B, Struzik E M, Purgat M B, Götz M and Olejnik I 2022 I4.0 technologies adoption: barriers and their impact on polish companies innovation performance. Eur. Plann. Stud. DOI:10.1080/09654313.2022.2068347
- [38] Doanh D C, Dufek Z, Ejdy J, Ginevicius R, Korzynski P, Mazurek G et al. 2023 Generative AI in the manufacturing process: theoretical considerations. Eng. Manage. Prod. Serv. **15**(4), 76-89. doi: 10.2478/emj-2023-0029.
- [39] Xu D L, Xu L E and Li L 2018 I4.0: state of the art and future trends. Int. J. Prod. Res. **56** (8), 2941-2962, DOI:10.1080/00207543.2018.1444806.
- [40] Lu Y 2017 I4.0: A survey on technologies, applications and open research issues. J. Ind. Inf. Integr. **6**, 1-10
- [41] Chae B K and Olson D 2021 Technologies and applications of I4.0: insights from network analytics. I. J. Prod. Res. DOI:10.1080/00207543.2021.1931524
- [42] Jayaprakash A, Shanu M, Meghna M k, Tamilarasan N and Balakrishnan J 2024 Impact of I4.0 on Indian's Automotive Sector: AI and Robotics integration. ICIMMI 2024: 6th International Conference on Information Management & Mach. Intell. (Rj, Jaipur, India December 23 – 24, 2024)
- [43] Kaya S M and Bayram V 2025 Artificial intelligence Awareness scale development study. OPUS J. society research. **22**(4), DOI: 10.26466/opusjsr.1680531
- [44] Gizealew D 2020 Artificial Intelligence towards Future Industrial Opportunities and Challenges. African Conference on Information Systems and Technology. **16**. <https://digitalcommons.kennesaw.edu/acist/2020/allpapers/16>
- [45] Kuman N, Chaudhary D, Kaur H and Yadav L A. 2023 Artificial Intelligence In Supply Chain Optimization. International Conference on IoT, Communication and Automation Technology (ICICAT). 979-8-3503-0282-0/23
- [46] Wanasinghe R T, Gosine G R, James A L, Mann G, Silva O and Warrian J. P 2019 The internet of things in the oil and gas industry: A systematic review. IEEE Internet Things J. in press
- [47] Liu Y and Xu X 2017 I4.0 and cloud manufacturing: A comparative analysis. J. Manuf. Sci. Eng. **139**

- [48] Maheshawari S, Gautam P and Jaggi K C 2020 Role of big data analytics in supply chain management current trends and future perspectives. I. J. prod. Res. DOI: 10.1080/00207543.2020.1793011
- [49] Dorduncu H and selinoruc Z 2021 I4.0, Digitalization and big data: perspective pf logistics and supply chain management. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, **30**, 170-180.
- [50] Lema T, Lemu H G and Gutema E M 2020 Assessment of awareness levels towards additive manufacturing best practices in transforming traditional manufacturing. A case study in Ethiopian context. IOP conferences Series. Mater. Sci. and Eng **1294**, 012045
- [51] Yamane Y 1967 Mathematical Formulae for Sample Size Determination.